APPLICATION OF FUEL LEAN GAS REBURN WITH SNCR ON A 198 MW COAL-FIRED UTILITY BOILER

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SUMMARY

Carolina Power & Light has installed a Fuel Tech Fuel Lean Gas Reburn (FLGR®) system with an integrated NOxOUT® Selective Non-Catalytic Reduction (SNCR) system on its 198 MW (net) Asheville Unit No. 1. The system was installed to further reduce NOx emissions below the level achieved with low-NOx burners (LNBs) that were installed in 1997. Due to vertical limitations in the boiler, LNBs were installed without over-fire air. After the LNB installation, the NOx emission rate was approximately 0.58 pounds per million Btu of gross heat input [lb/MMBtu] at full load. The target NOx reduction for the FLGR /SNCR system is an additional 52% reduction from the post-LNB baseline to 0.28 lb/MMBtu. The primary fuel is an eastern bituminous coal.

Parametric testing and short-term automatic operations showed that the target NOx emission of less than 0.28 lb/MMBtu was achieved at all loads. The average ammonia slip was as low as 3 ppm and no observable balance of plant impact was found. Further testing is planned to determine the most effective NOx control without any balance of plant impact.

PROCESS DESCRIPTION

Urea-SNCR Process

The predominant urea SNCR reaction is described as:

$$CO(NH_2)_2 + 2NO + 1/2\ O_2 \Rightarrow 2N_2 + CO_2 + 2H_2O$$

Urea + Nitrogen Oxide + Oxygen => Nitrogen + Carbon Dioxide + Water

Two key parameters that affect the process performance are flue gas temperature and reagent distribution. The NOx reducing reactions are temperature sensitive. By-product emissions can become significant at low temperatures while chemical utilization and NOx reduction decrease at excessively high temperature. Although the optimum temperature range is specific to each application, it is generally between 1600 and 2200 degF. The reagent needs to be distributed within this optimum temperature zone to obtain the best performance.

FLGR® Process

FLGR® is the injection of natural gas (replacing 3-10% of the total heat input) via turbulent jets into the upper furnace of fossil fuel boilers. Maintaining an overall fuel lean furnace environment eliminates the need for downstream completion air and helps prevent excessive carbon monoxide emissions. The FLGR® process was developed under the sponsorship of Gas Research Institute (GRI.)

FLGR® with Urea-SNCR

The injection of natural gas and urea has been shown to enhance the NOx reduction potential of the natural gas in utility boilers. The chemical kinetics mechanisms of FLGR® and SNCR have many of the same selective reactions. The injection of natural gas in hot, low oxygen furnace gas results in the formation of hydrocarbon radicals (CHi) and the subsequent formation of nitrogen radicals. The injection of urea (NH2-CO-NH2) results in the formation of similar nitrogen radicals. Both of these reagents reduce NOx to molecular nitrogen through a series of similar reactions.

The SNCR reactions are highly efficient in reducing NOx in a temperature window of 1600ºF to 2200ºF. Using natural gas as a carrier for the reagent widens the SNCR reaction temperature window. The low oxygen environment near the gas jet allows injection at higher temperature with limited oxidation to NOx. The natural gas combustion also increases the reaction rates of the critical chemical reduction mechanisms and decreases the chance of ammonia slip.

SNCR and FLGR® Injectors, Multi-Nozzle Lances

Three types of reagent injection are employed in this project: Combined FLGR®/SNCR wall injectors, SNCR wall injectors and Multi-Nozzle Lances. The FLGR®/SNCR injectors are designed to deliver gas and liquid. The SNCR injectors and the MNLs deliver the NOxOUT reagent using air as an atomizing medium.

PRELIMINARY TEST RESULTS

Parametric testing and short-term automatic operations was performed across the applicable load range at 207 MWg, 155 MWg, and 99 MWg (corresponding to 100%, 75%, and 48% MCR, respectively) and in automatic operation at all loads in the range.

The target NOx emission of less than 0.28 lb/MMBtu was achieved at all loads in various configurations. The average ammonia slip was as low as 3 ppm. Throughout the testing, the air heater pressure drop at the tested loads remained essentially constant, indicating no evidence of air pre-heater fouling.

Approximately 23% NOx reduction was achieved with 6% gas injection. Concentrations of CO were acceptable, below 400 ppm on average, for gas injection up to between 6% and 7% of the gross heat input. The total permissible gas injection depended on the excess air in the lower furnace as well as the hardness and volatility of the fuel.

At full load, using combined gas and urea injection, the target NOx emission rate of less than 0.28 lb/MMBtu was achieved. The NOx and ammonia profiles were not uniform at the economizer outlet with NH3 levels varying from less than 1 to as much as 12 ppm and NOx varying between 0.23 and 0.33 lb/MMBtu. As expected, the level of achievable NOx reduction at full load varied with the apparent baseline NOx, the upper furnace temperature and the coal characteristics.

At lower firing rates, the furnace becomes cooler, excess air is higher, and furnace residence time is longer. Lower temperatures and longer reaction times benefit both gas injection and NOxOUT injection, allowing increased performance with decreased secondary emissions. The higher excess air, however, makes it more difficult for natural gas to achieve and maintain locally fuel-rich pockets in the gas.

At 75% MCR, gas was injected up to 8% of the gross heat input with less than 100 ppm of CO. Subsequent urea injection dropped the NOx emission rate to below the target of 0.28 lb/MMBtu. NOx reduction from gas and urea injection at the lowest load (48% MCR) was more than 40% with NOx emission at less than 0.28 lb/MMBtu. The average ammonia slip was less than 5 ppm and CO was less than 100 ppm. NOx was further reduced to less than 0.25 lb/MMBtu, with a slight increase in ammonia slip.